HWA CHONG INSTITUTION
C1 Promotional Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	**21S**

CHEMISTRY

9729/02

Paper 2 Structured Questions

30 September 2021

Candidates answer on the Question Paper

Total: 1 h 5 min

Additional Materials: Data Booklet

INSTRUCTIONS TO CANDIDATES

Write your name and CT class on all the work you hand in.

Answer all questions in the spaces provided in this Question Booklet.

Write in dark blue or black pen. You may use a soft pencil for diagrams and graphs only.

Do not use staples, paper clips, highlighters, glue or correction fluid.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

A Data Booklet is provided.

You may use a calculator.

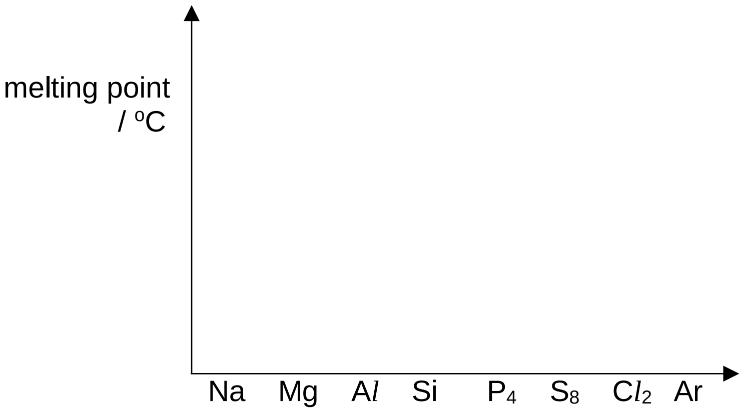
You are reminded of the need for good English and clear presentation in your answers.

FOR EXAMINERS' USE ONLY

Paper 1 (24.2%)	Paper 2 (38.7%)		Paper 3 (37.1%)		TOTAL
	Q1	/ 8	Q1	/ 20	
	Q2	/ 12	Q2 / Q3	/ 15	
	Q3	/ 20			
	Deductions (s.f.)		Deductions (total)		
	Deductions (units)				
	Deductions (margins)				
	Deductions (others)				100%
/ 20		**/ 40**		**/ 35**	

1 (a) (i) The elements in Period 3 range from metals on the left of the Periodic Table to non-metals on the right.

On the axes below, sketch the variations in melting point of the elements sodium to argon.



[1]

(ii) With reference to their structures and bonding, account for the variations in melting points of aluminium, silicon and argon.

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(b) A diagonal relationship is said to exist between certain pairs of diagonally adjacent elements in the second and third periods (first 20 elements) of the Periodic Table, due to similar electronegativity of the elements.

(i) With reference to shielding effect and nuclear charge, explain why beryllium and aluminium are said to have similar electronegativity.

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(ii) $AlCl_3$ can form a dimer, Al_2Cl_6, while $BeCl_2$ can form a polymer, $[BeCl_2]_n$, where n is an integer greater than or equal to 1. Bonds are formed in a similar manner in Al_2Cl_6 and $[BeCl_2]_n$.

Draw the Lewis structures of Al_2Cl_6 and $[BeCl_2]_3$ (which is a section of the polymer containing three repeating units).

Al_2Cl_6:

$[BeCl_2]_3$:

[2]

[Total: 8]

2 2-methylbut-1-ene reacts with iodobromide, IBr, at room temperature to produce two organic products which are constitutional isomers of each other.

(a) What is meant by the term *constitutional isomers*?

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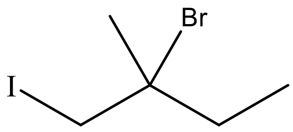
(b) **(i)** Given that **X** is the major product formed in the reaction above, describe the mechanism to form **X**. Show all charges and relevant lone pairs and show the movement of electron pairs by using curly arrows.



X

[3]

(ii) Suggest the structure of the minor product formed.

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(iii) Briefly explain why **X** is the major product.

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(iv) Deduce whether the sample of **X** formed in **(b)(i)** is optically active.

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(c) **(i)** Samples of 2-methylbut-1-ene were reacted with IBr. Several experiments were carried out at constant temperature and the initial rate of reaction was determined in each experiment as shown in Table 2.1 below.

Table 2.1

experiment	[2-methylbut-1-ene]/ mol dm^{-3}	[IBr]/ mol dm^{-3}	initial rate/ mol dm^{-3} s^{-1}
1	0.25	0.25	1.40×10^{-4}
2	0.50	0.25	2.80×10^{-4}
3	1.00	0.50	1.12×10^{-3}

Using the data given above, deduce the order of reaction with respect to 2-methylbut-1-ene and to iodobromide.

[2]

(ii) State and explain whether your answer in **(c)(i)** is consistent with the mechanism drawn in **(b)(i)**.

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(d) When a similar experiment was performed with Br_2 instead of IBr, the rate was found to be slower. Suggest and explain why this is so.

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[Total: 12]

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3 The solubility of a compound is the maximum mass of solute that can dissolve in 100 cm^3 of water to form a saturated solution. In a saturated solution, an equilibrium exists between the undissolved and dissolved solute. For example,

$$KClO_3(s) \rightleftharpoons KClO_3(aq)$$

Fig. 3.1 shows the relationship between the solubility of some compounds and temperature. Table 3.1 contains data on the standard enthalpy change of solution, $\Delta H^\ominus_{solution}$, of some of the compounds in Fig. 3.1.

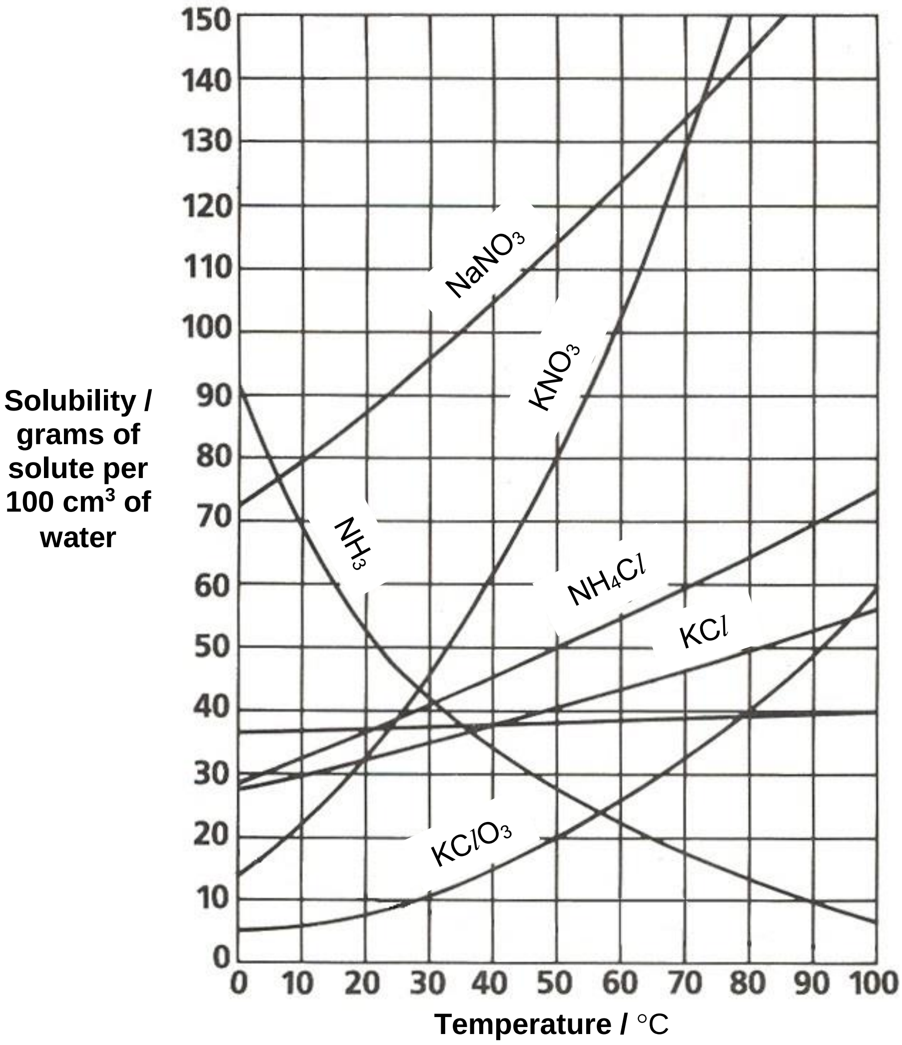

Fig. 3.1 Solubility curves of some compounds

Table 3.1

compound	$\Delta H^\ominus_{solution}$ / kJ mol^{-1}
$KClO_3$	+41.4
KNO_3	+34.9
KCl	+15.5
NH_4Cl	+14.8
NH_3	–78.2

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(a) Student A uses the information in Fig. 3.1 and Table 3.1 to propose the following hypothesis:

An endothermic $\Delta H^{\ominus}_{solution}$ is associated with a positive gradient in the solubility curve for the compound.

Student A says that this hypothesis can be explained by *Le Chatelier's Principle*.

(i) State *Le Chatelier's Principle*.

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(ii) Describe how *Le Chatelier's Principle* might be used to explain Student A's hypothesis.

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(iii) In reality, the sign of the standard enthalpy change of solution cannot be used to predict the relationship between the solubility of compounds and temperature. Explain why this is so.

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(iv) Student B proposes a different hypothesis based on the information in Fig. 3.1 and Table 3.1:

The greater the magnitude of $\Delta H^{\ominus}_{solution}$, the greater the change in solubility of the compound with respect to temperature.

From Fig. 3.1 and Table 3.1, select and state two compounds whose data do **not** support Student B's hypothesis, and explain your choice.

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(b) Using the information in Fig. 3.1, explain by a suitable calculation, why it is normally **not** possible to prepare an 8.5 mol dm^{-3} aqueous solution of KC*l*.

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(c) When KC*l* dissolves in water, attractive forces are overcome and new attractive forces form. An entropy change, ΔS, is associated with each of these two processes.

State and explain the sign of ΔS for **each** of these two processes, making reference to the attractive forces and species involved.

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(d) The standard enthalpy change of formation of **aqueous** ClO_3^- ions, $\Delta H^\ominus_f$ $ClO_3^-(aq)$, is defined as the enthalpy change when 1 mole of $ClO_3^-(aq)$ is formed from its constituent elements in their standard states at 298 K and 1 bar.

(i) Write a balanced thermochemical equation that illustrates the standard enthalpy change of formation of $ClO_3^-(aq)$.

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Some enthalpy change values are given in Table 3.2.

Table 3.2

	enthalpy change / kJ mol^{-1}
$\Delta H^\ominus_{solution}$ $KClO_3$	+41.4
lattice energy of $KClO_3$	–721.0
$\Delta H^\ominus_{hydration}$ K^+	–320.0
$\Delta H^\ominus_f$ $KClO_3(s)$	–391.4
$\Delta H^\ominus_f$ $K^+(aq)$	–251.2

(ii) Using relevant data from Table 3.2, calculate the standard enthalpy change of hydration of ClO_3^-.

[2]

(iii) Construct a suitable energy cycle and calculate the standard enthalpy change of formation of $ClO_3^-(aq)$, $\Delta H^\ominus_f$ $ClO_3^-(aq)$.

[3]

(iv) Using your answers in **(d)(ii)** and **(d)(iii)**, calculate the standard enthalpy change of formation of **gaseous** ClO_3^- ions, $\Delta H^\ominus_f$ ClO_3^-(g), with the aid of a suitable energy cycle.

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[2]

[Total: 20]

END OF PAPER